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Research paper

Brain knowledge and predictors of neuromyths among teachers in Morocco

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ABSTRACT

The objective of this study was to evaluate brain knowledge and the prevalence of neuromyths among teachers in Morocco. We aimed also predicting factors that may improve teachers' brain knowledge and widespread of neuromyths. An online questionnaire was sent to a large population of Moroccan teachers. The questionnaire contains 32 questions, 20 of them are designed to assess teachers' knowledge about the brain and the remaining 12 questions are neuromyths. The mean score of brain knowledge was (64.34% (SD = 27.9%)) and the mean score of neuromyths was (66.56% (SD= 25.73%)). Besides, 50% of teachers were unable to correctly answer seven out of the 20 brain knowledge questions. Moreover, half of the teachers believed in 9 out of the 12 neuromyths. Knowledge about the brain was the foremost predictor of neuromyths. The study disclosed a real lack of brain knowledge with a widespread of neuromyths among teachers in Morocco.

1. Introduction

Whether the 2002 OECD (Organization for Economic Co-operation, and Development) report encouraged and recommended “ Understanding the Brain: Towards a New Learning Science”, the 2007 one pronounce the birth and emergence of this new learning discipline [25,26] as the results of a wide collaboration between neurosciences and education. The actors in these two fields of knowledge made major debates and controversies, which crowns the birth of this new learning science: the Neuroeducation [1,7,13,14,15,16,17,24,31,32,35,37–40,42]. Indeed, the Neuroeducation is a multidisciplinary research field that joins education and neurobiology. Several studies recommend the consolidation of this collaboration to produce appropriate solutions to lead learning in the 21st century [2,3,9,18,19,34].

Great efforts have been made by neuroscientists to understand neural mechanisms that support learning processes. However, the successful transfer of these neuroscience data into the field of teaching and education is closely associated to teachers' knowledge on brain and its implications in teaching and learning mechanisms [6,12,30,36]. This has prompted several researchers in different countries to assess teachers' brain knowledge and estimate the prevalence of neuromyths among them. They also tried to predict the possible origins of this false knowledge about brain functioning in learning processes [10,28]. Indeed, the prevalence of neuromyths among teachers has been studied in a lot of countries with high and very high human development index such as Netherlands, Canada, United States of America, United Kingdom, Switzerland, French, Spanish, Greece, and Turkey [4,5,8,11,21,23,27,29,30,33,41]. These studies revealed a lack of brain knowledge; difficulties in translating the brain knowledge into learning situations and a widespread of neuromyths among teachers, which generates negative effects on student learning. These neuromyths influence teachers' pedagogical choices, and prevent them to benefit from effective pedagogical practices that are recognized and supported by scientific research. However, there is a dearth of data on the prevalence of neuromyths in low and middle-income countries.

To our knowledge, none study on the prevalence of neuromyths among teachers has been performed in Morocco. For this reason, it appears necessary to carry out this study in Morocco. Then, we have targeted three main objectives: First, assessing the level of knowledge about the brain and its implications in the learning processes among Moroccan classroom teachers. Second to appreciate the prevalence of neuromyths among teachers in Morocco. The third part of this investigation aimed to estimate the association between teachers' knowledge about the brain and the prevalence of neuromyths and look for other socio-demographic parameters that can predict knowledge about the brain and neuromyths. Additionally, *Kelly* [23], in a recent study, have shown that training in neuroscience can help to reduce belief in neuromyths. By simulation, we asked for the ability of science

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teachers, who are more exposed to neurosciences information, to reduce the spread of neuromyths among them.

2. Material and methods

2.1. Target population: inclusion and exclusion criteria

This is a cross-sectional study carried out among teachers in Moroccan elementary education. The first condition to participate in this study was being a teacher in the public elementary school (Primary, Middle and qualifying cycle) in Morocco. The participation in this study was deliberated according to the teachers' choices and willingness. So teachers working in higher education and training centers, as well as those working in private institutions are excluded from this study. Science teachers may be considered the most knowledgeable about neuroscience because they teach sequences of courses in this field in addition to the brain science training they have received throughout their study. We conducted a comparison of brain knowledge and the prevalence of neuromyths between science teachers and other subjects teachers.

2.2. The questionnaire

The scientific tool used in this study was a survey design inspired from [4] study [4]. The questionnaire contains 32 questions about brain functioning and the use of this knowledge in teaching, whose 12 are neuromyths. However, the remaining 20 assertions are real knowledge about how the brain works. The questionnaire was adapted to our situation and then transmitted to our interviewers.

The questionnaire takes into consideration the dimensions of the teachers' socio-demographic characteristics and it contains two sections: The first one contains questions about socio-demographic informations, specifically age, gender, diplomas (bachelors' degree, Bachelors', Masters' or Doctorate), as well as information concerning the seniority in the field of teaching, the grade level taught and the subject they teach. In the second section are gathered the issues of the brain knowledge in addition to the list of neuromyths. Brain knowledge statements and neuromyths are randomly mixed.

The teachers were invited to complete the questionnaire by checking the compatible boxes “True”, “False” or “Don't Know”.

2.3. Statistical analysis

The statistical analyses were carried out using the SPSS (Statistical Package for the Social Sciences “25 version”) software. We used a linear regression analysis to investigate the association between brain knowledge and Neuromyths prevalence as dependent variables and the socio-demographic parameters.

Group comparisons between science and other subjects teachers were conducted for the neuromyths and brain knowledge scores using *the Chi2* test, covarying for age, gender, diploma, teaching cycle and profession seniority. We used also linear regression to evaluate the association between brain knowledge and the prevalence of neuromyths. We used t student test to compare means of neuromyths items score and brain knowledge score between science teachers and other subjects teachers. The statistical significance in this study was fixed at $p<0.05$.

3. Results

3.1. Socio-demographic results

Table 1 summarized the distribution data of teachers' socio-demographic characteristics. After distributing the questionnaire, we were able to receive 330 responses. The male to female ratio was 1.46 (40.6% were women). All school subjects were covered with a very high percentage of science teachers (41.5%). Besides, 63.6% of the teachers involved in this study have bachelors' degree and 22.4% of them have a masters' degree. Teachers with baccalaureates (12.4%) and those with a doctorate (1.5%) were less represented in our sample. About 57% of our respondents had profession seniority less than 9 years.

Table 1
Socio-demographic characteristics of respondents.

		Number	Percentage%
Gender	Female (F)	134	40.6
	Male (M)	196	59.4
Age (years)	< 30 (A1)	101	30.6
	30- 39 (A2)	134	40.6
	40 −49 (A3)	56	17.0
	≥ 50 (A4)	39	11.8
Teaching cycle	Primary school teachers (P)	108	32.7
	Middle school teachers (C)	136	41.2
	Qualifying school teachers (Q)	86	26.1
Profession seniority (years)	< 5 (S1)	121	36.7
	5 – 9 (S2)	69	20.9
	10 −14 (S3)	41	12.4
	15 – 19 (S4)	35	10.6
	≥ 20 (S5)	64	19.4
Diploma	Baccalaureates (B)	41	12.4
	Ph.D. (D)	5	1.5
	Bachelor degree (L)	210	63.6
	Masters' degree (M)	74	22.4

Table 2

3.2. brain knowledge

The mean score of brain knowledge statements of the entire sample was 64.34% (SD = 27.9%). Among science teachers, the mean brain knowledge score was (65.34%, SD= 28.99%) and among all other subjects teachers, the mean knowledge score was (61.74%, SD= 27.36%). A large population in our sample poorly knew seven out of the 20 statements related to teachers' brain knowledge. These questions were incorrectly answered by over 50% of teachers. Among the 13 items remaining in the list of brain knowledge, the percentage of correct answers does not exceed 67% in only 4 statements.

To explore parameters that predict knowledge about the brain, we conduct a multiple regression analysis. Knowledge score as dependent variable and age, sex, teaching cycle and subjects as independents variables. Results from linear regression are disclosed in Table 3. This analysis revealed that age $B = 0{,}328$) and teaching cycle $B = 0{,}388$) are predictors of brain knowledge. Teachers' brain knowledge decreased with age. Further, the primary school teachers' score was lower than that among middle school teachers, but both were lower than qualifying school teachers' scores.

3.3. Prevalence of neuromyths

The mean score of incorrect answers on the list of neuromyths was 66.56% (SD= 25.73%). Half of the teachers in this study believed in 9 out of the 12 statements related to neuromyths. Items 7 and 8 were the most popular neuromyths believed among teachers with a percentage of correct answers barely reached 0.6% and 3% respectively. Correct answers of all other neuromyths didn't exceed 61%, except neuromyths 6 (71.8% of teachers were able to detect). Over 90% of teachers responded incorrectly to neuromyths 12 and 88.8% for Item 10. Among science teachers, the mean score of incorrect answers to the neuromyths list was 63.17% (SD = 28.09%) and it was 69.17 (SD = 24.06%) among other subjects teachers (Table 4).

3.4. predictors of neuromyths and groups' comparison

In order to explore the parameters that predict belief in neuromyth,

Table 2
Results of Brain knowledge.

Items	Correct (%)	Inaccurate (%)	Don't Know (%)
1- We use our brains 24 h a day (T)	66,7	32,1	1,2
2- Boys have bigger brains than girls (T)	23,3	73,9	2,7
3- When a brain region is damaged other parts of the brain can take up its function (T)	9,1	90,0	0,9
4- The left and right hemispheres of the brain always work together (T)	66,4	32,4	1,2
5- The brains of boys and girls develop at the same rate (F)	45,2	52,1	2,7
6- Brain development has finished by the time children reach secondary school (F)	72,1	23,3	4,5
7- Information is stored in the brain on a network of cells distributed throughout the brain (T)	44,5	52,7	2,7
8- Learning is not due to the addition of new cells to the brain (T)	62,4	34,5	3,0
9- Learning occurs through modification of the brains' neural connections (T)	83,3	12,4	4,2
10- Academic achievement can be affected by skipping breakfast (T)	95,5	4,2	0,3
11- Normal development of the human brain involves the birth and death of brain cells (T)	52,1	44,3	3,6
12- Mental capacity is hereditary and cannot be changed by the environment or experience (F)	95,8	3,6	0,6
13- Vigorous exercise can improve mental function (T)	95,5	3,3	1,2
14- Circadian rhythms ("body-clock") shift during adolescence, causing pupils to be tired during the first lessons of the school day (T)	85,5	11,8	2,7
15- Regular drinking of caffeinated drinks reduces alertness (T)	24,2	73,3	2,4
16- Extended rehearsal of some mental processes can change the shape and structure of some parts of the brain (T)	35,8	60,0	4,2
17- Individual learners show preferences for the mode in which they receive information (e.g., visual, auditory, kinesthetic) (T)	98,8	0,00	1,2
18- Production of new connections in the brain can continue into old age (T)	47,9	47,0	5,2
19- There are sensitive periods in childhood when it's easier to learn things (T)	96,1	1,5	2,4
20- When we sleep, the brain shuts down (F)	87,3	10,6	2,1

Table 3
Predictors of brain knowledge.

	B (SE)	*t*	*p*	95% CI for B	
				Lower	upper
Gender	0,328 (0,244)	1346	0,179	−0,151	0,807
Age	−0,450 (0,187)	−2408	0,017	-,818	−0,082
Profession seniority (years)	0,122 (0,130)	0,940	0,348	−0,133	0,377
Teaching cycle	0,388 (0,192)	2022	0,044	0,010	0,766
Diploma	−0,156 (0,218)	−0,715	0,475	−0,585	0,273

we conduct a multiple regression analysis (Table 5). Neuromyths score as dependent variable and age, sex, teaching cycle, subject and brain knowledge score as independent variables. This analysis showed an association between brain knowledge score and the neuromyth score. ($B = 0,230$). Good knowledge about the brain lead to a decrease in the endorsement of neuromyths. This analysis showed that gender also predicts neuromyths score ($B = 0,574$). Females are more likely to believe in neuromyths than males. Furthermore, science teachers seem to believe in neuromyths less than all other subjects teachers.

The comparison of correct answers means on neuromyths between science teachers and those teaching other subjects showed a significant difference (Fig. 1).

Table 5
Predictors of neuromyths.

	B (SE)	*t*	*p*	95% CI for B	
				Lower	upper
Gender	0,574 (0,196)	2937	**0,004**	0,190	0,959
Age	0,176 (0,151)	1164	0,245	−1286	−0,415
Profession seniority (years)	−0,025 (0,104)	−0,238	0,812	−0,229	0,180
Teaching cycle	0,052 (0,155)	0,335	0,738	−0,253	0,356
Diploma	−0,207 (0,151)	−1187	0,236	−0,551	0,136
Knowledge About the brain	0,230 (0,045)	5078	<**0,001**	0,141	0,319
Subject	−0.723 (0.198)	- 3.661	<**0.001**	−1.112	−0.335

The comparison of sciences and other subjects teachers groups according to their socio-demographic and professional characteristics were summarized in Table 6.

4. Discussion

Throughout this study, we aimed to evaluate teachers' knowledge about the brain and its application in teaching and learning processes and the prevalence of neuromyths among teachers in Morocco. We also

Table 4
Neuromyths Items list.

	Correct (%)	Incorrect (%)	Don't Know (%)
1- Children must acquire their native language before a second language is learned. If they do not do so either language will be fully acquired.	50.9	47.3	1.8
2- If pupils do not drink sufficient amounts of water (=6–8 glasses a day) their brains shrink.	49,4	47,9	2,7
3- It has been scientifically proven that fatty acid supplements (omega-3 and omega-6) have a positive effect on academic achievement.	17,3	80,3	2,4
4- We only use 10% of our brains.	28,8	69,1	2,1
5- Differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners.	49,7	47,3	3,0
6- There are critical periods in childhood after which certain things can no longer be learned.	71,8	26,1	2,1
7- Individuals learn better when they receive information in their preferred learning style (e.g., auditory, visual, kinesthetic).	0,6	98,8	0,6
8- Environments that are rich in stimulus improve the brains of pre-school children.	3,0	95,2	1,8
9- Children are less attentive after consuming sugary drinks and/or snacks.	43,6	53,9	2,4
10- Exercises that rehearse co-ordination of motor-perception skills can improve literacy skills.	8,2	88,8	3,0
11- Learning problems associated with developmental differences in brain function cannot be remediated by education.	60,6	34,8	4,5
12- Short bouts of co-ordination exercises can improve the integration of left and right hemispheric brain function.	7,6	90,0	2,4

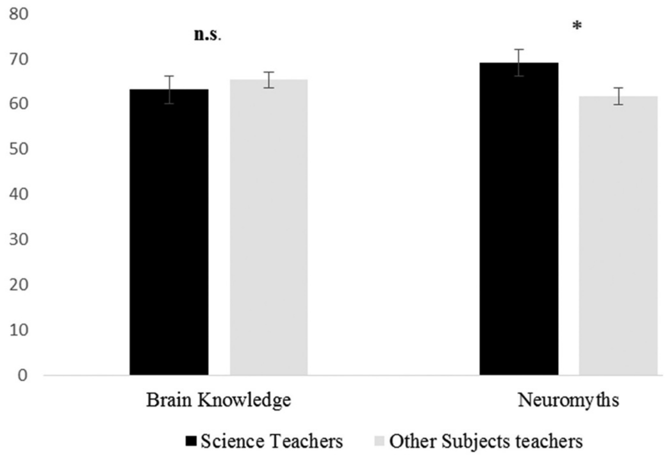

Fig. 1. Comparison of mean brain knowledge and neuromyths between science and other subjects teachers. Errors Barres refers to the standard deviation. * $p <$ 0.5; (n.s: Not significant).

try to predict the origins of possible misconceptions about the brain. The results obtained show poor knowledge about the brain among teachers in Morocco. The study disclosed a close association between the level of brain knowledge and the prevalence of neuromyths: surprisingly having good knowledge about the brain leads to a high prevalence of neuromyths. On one hand, we found that gender and taught subjects constitute additional predictors of neuromyths; but the remaining sociodemographic characteristics didn't predict neuromyths. On the other hand, age and teaching cycle constituted the main predictors of brain knowledge among teachers in Morocco.

The mean score of brain knowledge among Moroccan teachers was higher than that recorded among Spanish teachers [8] and lower than that of the Uk, Nederland [4], Greece [5,27] and Latin America teachers [11]. As mentioned in the results section above, seven items out of 20 questions in the list of brain knowledge were unwell known by over 50% of teachers, which showed a weak in brain knowledge among teachers in Morocco. The gap knowledge about the brain has previously been reported in several studies [4,5,8,11,21,23,27,29].

Among science teachers, there was an improvement in the brain knowledge score (65.34%, SD= 28.99) compared to that recorded among other subjects teachers (61.74%, SD= 27.36). The difference can be explained by the fact that science professors teach sequences of courses on neuroscience, which improves their knowledge about the brain. This corroborates the results of the USA study that showed good knowledge about the brain in the pre-exposed population to neuroscience compared to educators [23].

The mean score of false responses on neuromyths statements changes from one country to another. The high scores obtained in many countries proves a wide spread of neuromyths among the teaching community around the world. Although, the rich environment and learning style are the two most popular neuromyths that have been reported in all studies conducted in several countries. Statements 10 and 12 in the list of Neuromyths assertions are also very popular among teachers in most countries. Among teachers in Morocco, we recorded the highest rate of false answers concerning the last four neuromyths in comparison with Europe countries, the USA state, and Latin America countries [4,5,8,11,21–23,27,29]. This confrontation shows a wide spread of neuromyths among teachers in Morocco and therefore constitutes an alarming signal to fight against these misconceptions and then to limit their harmful effects on students learning.

The regression analysis revealed that the brain knowledge score predicts neuromyths score. All studies on neuromyth prevalence and brain knowledge conducted in many countries have shown a close association between teachers' level of knowledge about the brain and the prevalence of neuromyths. However, despite the use of the same methodological tool, the form of this association is controversial. Some studies showed, unexpectedly, a positive association [4,8,11], while others were reporting a negative correlation [27]. We showed, also, a positive association between teachers' brain knowledge and the prevalence of neuromyths. Good knowledge about the brain doesn't prevent teachers to have neuromyths beliefs.

In addition, a significant difference in neuromyths between science teachers and other subjects teachers despite their similar means of brain knowledge. Science teachers have the opportunity to benefit from courses related to neuroscience in their university curriculum in addition to teaching sequences of courses related to neuroscience and therefore have more access to neuroscience data.

Items related to brain knowledge and those related to neuromyths are randomly mixed in the same questionnaire to avoid any acquiescence bias reported in a previous study [8]. However, the lack of didactic resources proposed by Ferrero et al., [8] to explain the low Spanish teachers' score on the brain knowledge, may partly explain the low score obtained by our population [8]. This proposal supported the score obtained by science teachers, supposed having high neuroscience

Table 6
Groups' comparison.

	ST	OST
Brain knowledge Items		
1-We use our brains 24 h a day. (T)	24.8 c	37.4 f
3-When a brain region is damaged other parts of the brain can take up its function. (T)	94.2 f	87.4
4-The left and right hemispheres of the brain always work together. (T)	29.2	34.1 e
6-Brain development has finished by the time children reach secondary school. (F)	21.2	22.5 de
7-Information is stored in the brain in a network of cells distributed throughout the brain. (T)	51.1 e	54.4 d
8-Learning is not due to the addition of new cells to the brain. (T)	30.7	36.8 f
12-Mental capacity is hereditary and cannot be changed by the environment or experience. . (F)	2.2	4.4 a
13-Vigorous exercise can improve mental function. (T)	2.9	3.8 c
14-Circadian rhythms ("body-clock") shift during adolescence, causing pupils to be tired during the first lessons of the school day. (T)	8.8	14.3 e
15-Regular drinking of caffeinated drinks reduces alertness. (T)	75.2	72.5 e
18-Production of new connections in the brain can continue into old age. . (T)	38	53.8 e
19-There are sensitive periods in childhood when it's easier to learn things. (T)	1.5 e	1.6
Neuromyths Items		
2-If pupils do not drink sufficient amounts of water (=6–8 glasses a day) their brains shrink.	46 d	51.1
3-It has been scientifically proven that fatty acid supplements (omega-3 and omega-6) have a positive effect on academic achievement.	77.4 ae	82.4 d
4-We only use 10% of our brains.	67.9 e	70.3 f
5-Differences in hemispheric dominance (left brain, right brain) can help explain individual differences amongst learners.	38.7 e	53.8
9-Children are less attentive after consuming sugary drinks and/or snacks.	46 a	60.4 df
10-Exercises that rehearse co-ordination of motor-perception skills can improve literacy skills.	85.4	91.2 a

ST: science teachers; OST: Other subjects teachers; abcdef: Gender (a), subject (b), cycle (c), profession seniority (d), age (e) and education (f); $p < 0.05$.

exposure. The widespread of these misconceptions about the brain among teachers in Moroccan can be also justified by the reluctance of teachers to read specialized scientific articles and magazines on one hand; and their use of unreliable sources of information on the other hand [20].

The regression analysis disclosed that gender and taught subjects are predictors of neuromyths. As reported in previous studies, women are more likely to believe in neuromyths [8,23]. The results showed that general brain knowledge was predicted by age and teaching cycle. Brain knowledge decrease with age. Young teachers may have more neuroscience information than older ones. In addition, qualifying school teachers were more scored in brain knowledge than their peers of middle and primary schools.

5. Conclusion and perspectives

A lack of brain knowledge has been highlighted among teachers in Morocco. This lack of brain knowledge is associated with a widespread of neuromyths among teachers population. Knowledge about the brain is the main predictor of neuromyths among our sample. Although there is no significant difference in the mean knowledge score about the brain among science teachers and their peers of other subjects; teaching science prevents teachers to believe in neuromyths.

6. Recommendations

The lack of knowledge about the brain and the widespread of neuromyths among the teaching population has negative effects on student learning through inappropriate pedagogical choices in the classroom. To battle these misconceptions about the brain and those negative implications in learning processes it appears necessary to integrate educational neuroscience courses into the teacher-training curriculum.

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